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UNITED STATES DEPARTMENT OF AGRICULTURE

GRASSHOPPERS AND THEIR CONTROL ON SUGAR BEETS AND TRUCK CROPS

See revised
edition



SUGAR BEETS and garden crops grown in the semiarid regions of the States west of the Mississippi River are subject to frequent injury by several kinds of large native grasshoppers. The severity of this injury varies with the season and locality, but has been found to increase with the settlement of these regions. Especially is this the case where irrigated crops are surrounded by uncultivated pasture or waste areas where destruction of the egg masses during the winter is impracticable. Such crops naturally concentrate the grasshoppers from a considerably greater area, with serious injury as the result.

In view of the probability of increased losses from these pests, this bulletin has been prepared, which gives a sufficient account of the life history to afford thorough understanding of the control measures advised. Especial attention is directed to the value of neighborhood or community effort in controlling a group of pests originating, as do these, in areas from which extended migration is infrequent if not impossible. Given an intelligently applied and timely campaign by the entire community, each year that indications point to a serious grasshopper invasion, the losses from this source may be easily kept at a minimum.

Contribution from the Bureau of Entomology

L. O. HOWARD, Chief

Washington, D. C.

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GRASSHOPPERS AND THEIR CONTROL ON SUGAR BEETS AND TRUCK CROPS.

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WHERE GRASSHOPPER INJURY IS MOST SEVERE.

MANY PARTS of the United States may suffer the loss or injury of crops through grasshoppers, but the area having an annual rainfall of less than 25 inches is especially subject to their attacks. This includes

the country lying west of the Mississippi, with the exception of a strip from 100 to 200 miles wide bordering the river, and a portion of the northern Pacific States. In the eastern part of the semiarid region grasshoppers usually occur about equally in upland and lowland crops. In the drier sections farther west they have become

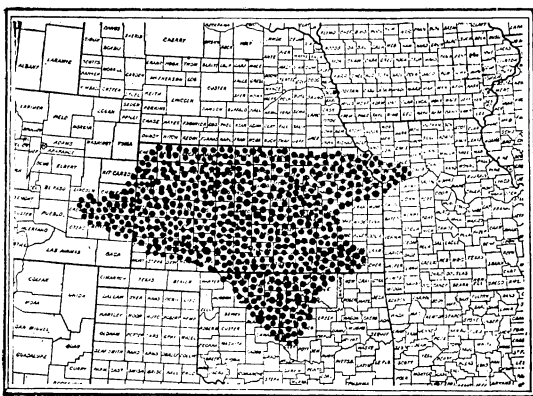


FIG. 1.—Map of Kansas and neighboring States, showing location of grasshopper outbreaks during the years 1911, 1912, and 1913.

established only along water courses and in other favored places where there is enough herbaceous vegetation to feed them through the summer. From here they spread immediately into localities developed through dry-land farming and irrigation.

Grasshopper ravages are relatively much more serious in dry regions than in humid, as the lack of moisture prevents recovery when crops are damaged. Recent outbreaks over most of this area

¹ Resigned December 31, 1919; revision prepared by Truck-Crop Insect Investigations.

semblance in markings and habits to its destructive relative, the Rocky Mountain or migratory grasshopper. Its body is from three-fourths to 1 inch long, and is yellowish-brown with darker mark-



FIG. 3.—Two-lined grasshopper: Adult. Enlarged.

ings. There is a resemblance between this species and the red-legged grasshopper, which is found over about the same territory. The type may be recognized by the dark band on the front two-thirds of the upper half of the neck, a light stripe on each side from the base of the wing to the socket of the hind leg, and three dark bands across the top and down each side of the hind thighs. Through the center of each front wing a light stripe runs lengthwise, widening backward, and containing several squarish dark patches.

The thick-set body of the Bruner grasshopper (fig. 4) is about 1 inch in length and is of a greenish-yellow color. Three bluish-green stripes extend from the head backward across the neck, one on top and one on each side. The front wings are olive green, finely netted with yellow cross-veins, and with a wedge-shaped area lengthwise through the center, bearing light and dark patches. Three bluish-green zigzag stripes on the hind thighs extend across the upper surface and down on each side.

EGG LAYING.

Between the time of maturity, which differs for each species, and freezing weather the females deposit their eggs, selecting for this purpose firm soil in a well-drained location. A hole is formed by working the abdomen downward and backward into the soil as far

as it will go, and the eggs are deposited therein, one at a time, as the abdomen is slowly withdrawn. (Fig. 5.) A white, frothy liquid, deposited with the eggs, fills the spaces among them and moistens the

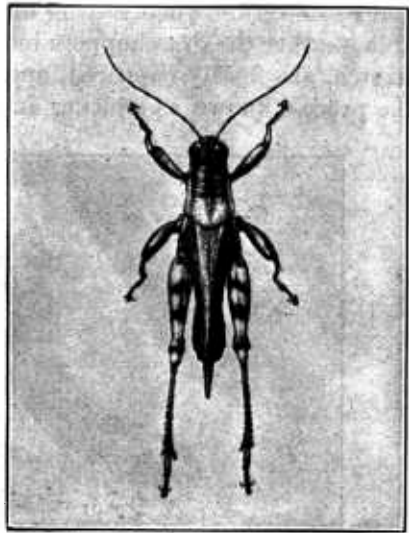


FIG. 4.—The Bruner grasshopper: Adult. Enlarged.

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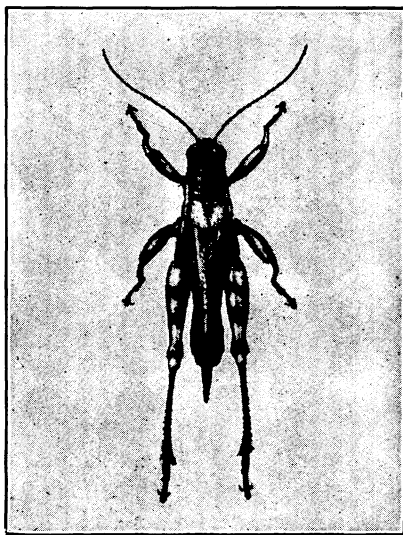


FIG. 4.—The Bruner grasshopper: Adult. Enlarged.

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walls of the hole. As the liquid dries, it hardens, cementing the yellowish-brown eggs and moist soil into a curved, cylindrical capsule. (Figs. 6, 7.) Abandoned fields, turn rows, the undisturbed



FIG. 5.—Differential grasshopper laying eggs. Enlarged.

strips under fences, along neglected roadsides (see fig. 8), and on banks of irrigating ditches, and buffalo sod along the edges of infested fields are favorable places for egg laying.

DEVELOPMENT.

The eggs hatch about the time of the last spring frosts, when warm weather is assured. The young grasshoppers push upward to the surface and soon begin feeding on the nearest vegetation. At first they are from one-eighth to three-sixteenths of an inch long and almost white. Exposure to light and air soon develops dark patches in the skins, which make them difficult of detection when resting on soil or dead vegetation. In favorable weather the grasshoppers increase rapidly in size. The old skins stretch, are finally ruptured, and the young insects escape. This is the process known as molting and occurs five times before the grass-



FIG. 6.—Egg capsules of the differential grasshopper, enlarged $1\frac{1}{2}$ times.

hoppers are full grown. The newly acquired skins are very elastic for a short period after molting, and during this time there is a further rapid increase in size. The wing pads on the sides of the

body above the legs become larger with each molt, the wings being fully developed after the last molt has taken place.

HABITS.

The young grasshoppers are most active on clear, warm days, during which they feed much of the time. At night and during cool days they seek shelter among standing vegetation or under rubbish and clods. They travel by jumping and crawling and are exhausted by slight exertion.

The adults of the lesser migratory grasshopper can fly long distances, but never do so except in search of food or to escape unfavorable conditions. The adults of the other three species mentioned have wings that are small in proportion to the size of their bodies and they can not fly far. Only a lack of food or very unfavorable surroundings will produce a migration to any great distance. Lack of suitable ground in which to deposit eggs may produce short migrations in all species, but it is probable that all of our injurious native species remain within 1 mile of their birthplace.



FIG. 7.—Egg capsules of the Bruner grasshopper $1\frac{1}{2}$ times natural size. 1, dorsal view; 2, lateral view; 3, ventral view; 4, dorsal view of eggs in capsule; 5, lateral view of eggs in capsule.

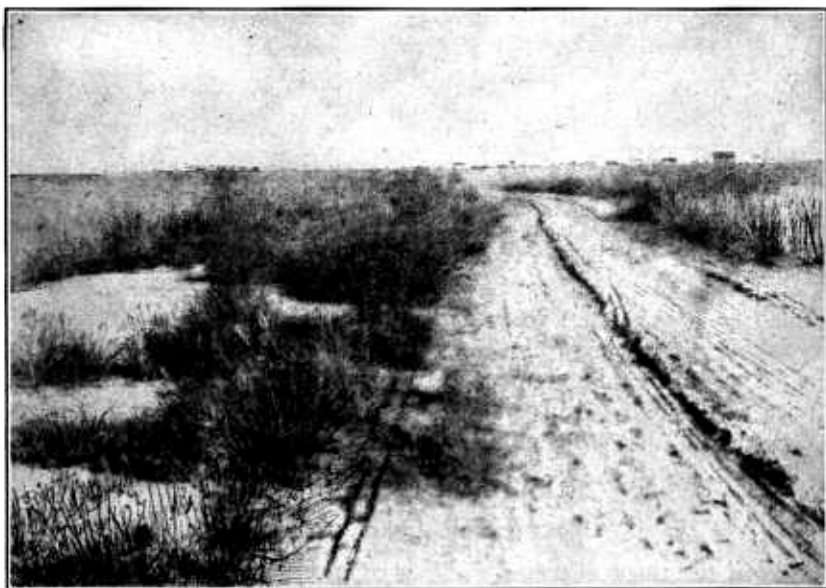


FIG. 8.—A neglected roadside. Russian thistles, sagebrush, and other weeds, interspersed with buffalo sod, form an ideal breeding ground for grasshoppers.

CLIMATIC CHECKS.

After grasshoppers become established in a locality they will not starve during an ordinary drought. The variety of plants they can use for food enables the young to mature if any vegetation starts in the spring. After maturity the adults can always find enough food to keep them alive until the eggs are laid.

When exposed to the sun on hot days, soft dirt, with hard dry soil below, reaches a temperature above 150° F. Grasshoppers can not deposit eggs in such hot soil and therefore seek shaded ground for egg laying. This sometimes results in eggs being placed in poorly

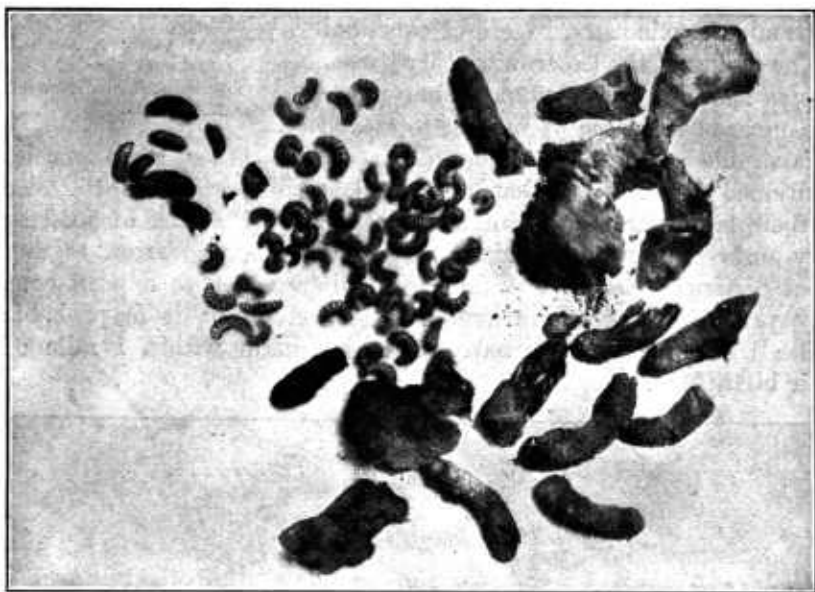


FIG. 9.—Grasshopper egg capsules and the bee-fly larvæ and coarctate larvæ of blister beetles that were collected along the roadside shown in figure 8; 53 of these parasitic larvæ were found in the grasshopper egg capsules collected in one hour. About natural size.

drained or heavy land, while others are placed in soil that becomes overheated later. In either case the vitality of the eggs is materially affected, often to the extent of being destroyed, as was noted during the hot weather of 1913, which was partly responsible for the reduction in the number of grasshoppers hatching the following year.

NATURAL ENEMIES.

ENEMIES OF THE EGGS.

Two of the most effective enemies of grasshopper eggs in Kansas are the larvæ of the bee flies¹ and those of blister beetles.² (See figs. 9 and 10.) These are white, grublike creatures that burrow

¹ Family Bombyliidae.

² Family Meloidae.

into the capsules when fresh and feed upon the grasshopper eggs until they attain full growth.

A small wasplike parasite,¹ from one-eighth to three-sixteenths of an inch long, has been reared from the eggs of the differential grasshopper, the two-lined grasshopper, and others. The female parasites cling to the bodies of female grasshoppers until the latter lay their eggs. As a grasshopper digs the tunnel in which to deposit her eggs the parasites crowd into it along her abdomen, and thrust their eggs singly, one into each grasshopper egg. The developing parasites then feed on the contents of the grasshopper eggs, destroying them.

Small rodents (mice, ground squirrels, and perhaps many others) and moles dig over egg-infested land, especially around the bases of weed stalks, to secure the capsules for food. Skunks share in this work, as indicated by the larger holes, footprints, and other traces. Hogs also eat the eggs and will turn the soil over thoroughly to obtain them.



FIG. 10.—Blister beetles: Coarctate larvæ (winter stage) of several species, $1\frac{1}{2}$ times natural size. At bottom are two as found, partly within the grasshopper egg capsules. Most blister-beetle larvæ before transforming burrow some distance from the egg capsules in which they feed.

ENEMIES OF THE YOUNG AND ADULTS.

A red mite, which is reported to have destroyed many of the Rocky Mountain grasshoppers during the seventies, does not kill

¹ *Scelio monticola* Brues.

many of our native species. The writer counted 135 of these mites on a single adult grasshopper which was still very active.

Young grasshoppers are frequently stung by female wasps, paralysis follows, and they are then stored to nourish the wasp larvæ. Several dozen helpless young grasshoppers have been dug from a single wasp burrow. The larger spiders as well as ground beetles feed on such grasshoppers as they can secure. Parasitic flies deposit their eggs or living young on the grasshoppers and the maggots enter the body and feed until grown, when they tear their way out, killing the grasshopper. These flies become very abundant in the fall of years of severe grasshopper outbreaks.

Toads, practically all lizards, and some snakes, feed to a considerable extent on grasshoppers. Cats and ground squirrels have been seen to catch and eat those of the larger species. Birds, practically all of which feed upon grasshoppers, destroy large numbers of both young and adults.

In some places chickens, turkeys, and guinea fowl are raised to catch them, constituting one of the most practical means of checking their outbreaks.

The chinch-bug fungus is known to kill large numbers of grasshoppers. In localities of eastern and central Kansas the differential and two-lined grasshoppers were almost wiped out by this disease during the fall of 1911. While the Bruner grasshopper was maturing during June of 1913, many nymphs and adults were killed by it. Reports of grasshoppers dying in western Kansas during the same period indicated a widespread outbreak of the disease. Its presence among the grasshoppers is easily recognized, as the dead insects remain clinging to the tips of weeds and grass, sometimes several in a cluster.

CONTROL MEASURES.

The control measures herein recommended are the most effective that were tried in Kansas during the years 1911 to 1914, and when carefully applied the value of the crop saved will be several times the cost of application. These measures come under two heads: (1) Destroying the grasshopper eggs, and (2) destroying the young and adult grasshoppers.

DESTROYING THE EGGS.

PLOWING.

If egg-infested land requires plowing for the next crop, no other treatment need be given. The plowing should be at least 6 inches deep, however, and should be finished as much before April 15 as possible. This covers the eggs so deeply that the young can not get out when they hatch.

HARROWING AND DISKING.

If plowing is unnecessary for the following crop, the eggs can be destroyed with little expense by stirring the ground to a depth of about 2 inches by March 1. This breaks and crushes many capsules and exposes others to the attacks of enemies and disease, as well as to drying and freezing. In clean ground that is soft enough a heavy harrow will stir the soil sufficiently. Three or four sections drawn by five horses will cover the ground rapidly. In heavy soils, weedy fields, alfalfa, or land in which patches of sod occur, the disk harrow is required; but in alfalfa it should not be set deep enough to cut off the crowns of the plants. The land should be left rough to expose as many eggs as possible, and after hard freezing weather it should be harrowed to expose any eggs that may have been covered before.

It is difficult to destroy eggs in buffalo sod. Breaking is not usually done deep enough to keep the young from escaping or the slices of sod are not left close enough together. No other cultivation can be given sod land. Hogs will root out and eat some of the eggs, but their use is not practicable for a large area. The egg-infested sod should be left until the young have hatched, when they can be killed by burning or by one of the other methods recommended for their destruction. Scattered clumps of egg-infested grass in turn rows, under fences, in abandoned fields, or along roadsides should be chopped out before March 1 with a heavy hoe or a spade.

DESTROYING THE YOUNG AND ADULT GRASSHOPPERS.

POISONED BRAN MASH.

Poisoned bran mash has been used against grasshoppers for many years with varying success. In 1911 and 1912 the writer, then with the Kansas Experiment Station, tested different methods of preparing and applying it, the results indicating that the addition of citrus fruits made it much more attractive to grasshoppers and that when sown broadcast one application killed from 50 to 100 per cent of those on the treated land. These results were confirmed during the severe grasshopper outbreak of 1913, more than 1,000 tons of bran being used in Kansas alone. Since then the formula has been used throughout the United States and Canada with uniformly good results. Other investigators have discovered that sawdust may be substituted for half or more of the bran and that where citrus fruits (oranges, lemons, and limes) are not available, tomatoes, canteloupes, melons, bananas, and perhaps other substances may be used to advantage.

The standard formula is given below, with the quantities of ingredients that are most conveniently handled under farm conditions. As much water should be used as the bait will hold without any draining off and wasting the poison. In arid sections and when it

is very dry this will be as much as 1 gallon to 6 pounds of bran, but this varies when substitutes are used instead of bran, and is always less in humid regions.

Bran	pounds--	25
Paris green or white arsenic	pound--	1
Oranges or lemons		6
Cheap sirup or molasses	quarts--	2
Water	gallons--	3

Mix the dry bran and poison in a washtub. Add the sirup and the juice and finely chopped pulp and peel of the fruit to the water. Then pour the water over the mixture of bran and poison, stirring to dampen it thoroughly and add as much more water as the bait will hold, usually about 1 gallon. While fresh, the wet fruity mash is very attractive to grasshoppers; but when dry or stale it is not eaten. The bait is applied by sowing it broadcast on the infested land late in the evening or early in the morning. Very early morning is to be preferred, as the grasshoppers are then just beginning to feed, and they have a longer time to eat before it dries than if it were applied at any other time. The bait should not be spread just before a shower, as rain washes the poison from the bran flakes, leaving them harmless. Little of the bait is eaten after the first day, even in damp weather. Therefore several applications may be necessary to check damage by grasshoppers in badly infested fields, or to keep injurious numbers from drifting into a field.

The amount of bait prepared by using the quantities of ingredients given in the formula will sow 6 acres of heavily infested land. This makes the cost of one application about 25 cents per acre. Ordinarily this amount should be spread over about 12 acres, which reduces the cost to 15 cents per acre or less. When the bait is to be applied a small quantity of known weight should be mixed and sown that it may be ascertained how very little is required when only 2 to 4 pounds of bran are to be used to the acre.

Cautions.—Neither domestic animals nor birds can secure enough of the poisoned bait to kill them, if it is scattered evenly as directed. Nevertheless, a few cautions regarding its use may not be out of place. It should never be placed in heaps or scattered thickly. The poison and mixed bait should be kept out of the reach of children and of domestic animals. Utensils used in handling the bait should be thoroughly scrubbed before being used for any other purpose. The dry, powdery poisons should not be exposed to the wind or handled roughly or carelessly. The bran and poison should be mixed with a spade or wooden paddle. If the hands are used for this purpose enough poison may be absorbed by the back of the hands and the forearms to cause severe intestinal cramps and diarrhea. The writer, however, has never known poisoning to occur simply from sowing the wet bait barehanded.

Where large areas have to be covered or when time is extremely limited, a device improvised during the grasshopper campaign in western Kansas, in 1916,¹ will materially reduce the labor required in applying poisoned bran mash. The apparatus is constructed after the manner of an alfalfa seeder used in that section and has many times proved its value, one man covering as much ground with it as three men distributing poison by hand.

The distributor (fig. 11) consists of a canvas bag which is strapped over the shoulders of the operator and is fitted with a feeding device consisting of a canvas sleeve and a swinging tube made of tin or galvanized iron, as shown in the drawing. A closely woven grain sack furnishes fairly good material for the bag. By careful experimentation it has been found that a machine constructed as here described scatters the mixture properly and evenly and covers ground rapidly. The bag may be made of a convenient size. The dimensions of the metal tube are as follows: Length, 28 inches; diameter at upper end, $2\frac{1}{2}$ inches; diameter at lower end, $1\frac{1}{8}$ inches. Over the opening at the lower end are soldered two short wires bent in the shape of a U and crossing each other at right angles at exactly the center and about 1 inch below the opening of the tube. These should be soldered both to the edge of the tube and together where they cross. Their purpose is to scatter the mixture evenly and thinly as it leaves the tube, which is swung by the operator. The canvas sleeve is 12 inches long, 13 inches in circumference at the upper end, and 8 inches at the lower end, which fits tightly over the upper end of the metal tube. These dimensions allow the mixture to work down into the tube and permit the tube to be swung over the half of a circle by the operator when walking through the field. On a still day the poisoned bran mash in this way may be scattered evenly and thinly over a strip of ground 60 feet wide. This enables one to cover an infested field in a short time and to do the work very thoroughly. A distributor of the foregoing dimensions will distribute poisoned bran mash at the rate of about 5 pounds to the acre, which is recognized as an efficient dosage under western Kansas conditions. The mixture can be sown thickly or thinly, depending upon the rapidity with which the operator walks through the field. Where grasshoppers are very numerous, by walking slowly and whirling the

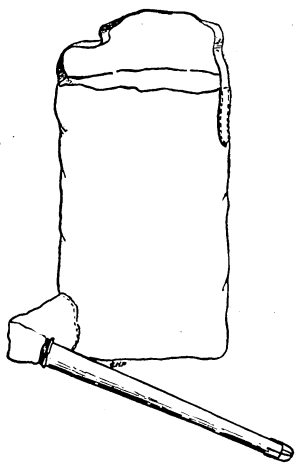


FIG. 11.—Distributor for poisoned bait.

¹ Brooks, T. H., *Journal of Economic Entomology*, vol. 10, p. 524, 1917.

tube regularly, the mixture can be applied much more thickly than where the grasshoppers are less abundant and where a natural gait is maintained by the operator. *It is necessary to have the oranges or lemons used in the bait ground through a meat chopper in order to prevent the tube from becoming stopped by the peelings in case this machine is used.*

THE HOPPERDOZER.

The hopperdozer is an old device for using kerosene, crude oil, or tar in catching grasshoppers and was developed during the migratory grasshopper years of 1874-1876. It consists of shallow sheet-iron pans, containing the oil or tar, which are mounted on low wheels or sled runners. An upright screen at the back catches the "hoppers" as the machine is drawn forward.

The hopperdozer is simple in construction. (See fig. 12.) The pan is made by turning up 6 inches of the edge of a sheet of galvanized

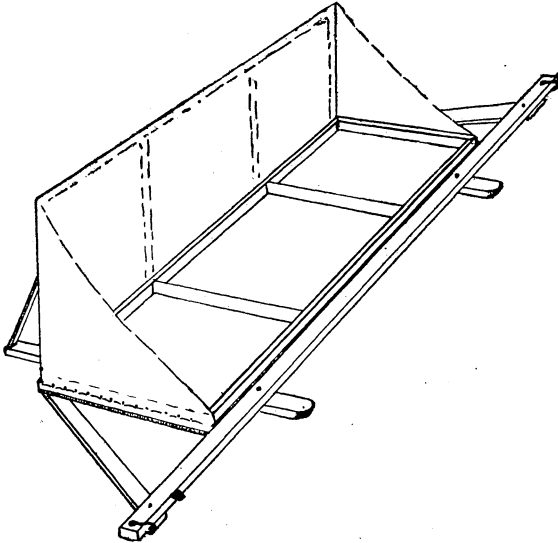


FIG. 12.—A successful type of horse-drawn hopperdozer.

iron, 8 feet long and 30 inches wide. Two inches of the edge is then turned down over the pan to prevent slopping, and two partitions soldered across it to keep the liquid from running to one end and spilling when operated on sloping ground. The sled floor is $18\frac{1}{2}$ inches from front to rear, being made of one board 1 by 6 inches and one 1 by 12 inches with a narrow

space between. It can be either 8 or 15 feet long to hold either one or two pans. A strip 1 by 4 inches on edge around it keeps the pans from sliding off. The runners are pieces of 2 by 4 lumber 4 feet long, laid flat and rounded at the front ends. They should extend about equal distances in front of and behind the floor. An 8-foot sled needs two runners and a 15-foot sled needs three. The screen behind the pans should be of oilcloth, smooth side forward, nailed to uprights at the back of the sled. The hitch is made by nailing a 2 by 4 across the runners in front of the pan and letting

the ends project 2 or 3 feet at each side. Each end is braced by a board extending to the end of the runner behind the pan.

For use, the compartments of the pan should be half filled with water and enough kerosene or crude oil should be added to form a film. If tar is used, a thin layer is spread in the bottoms of the otherwise empty pans. As the hopperdozer is drawn forward the grasshoppers jump up and fall into the pan, or strike against the screen at the back and drop in. Contact with a little tar or a wetting with the oil kills them, even though they jump out afterwards. The dead that collect must be shoveled out at intervals and the tar or oil and water replaced.

When large fields of fairly level land are to be treated with the hopperdozer, two or three pans are often set on the teeth of a sweep rake. This makes the work easy for the team, but on rough ground the liquid slops badly. In such cases two sleds holding two pans each, having for runners pieces of 2 by 4 set on edge, should be placed end to end. The two adjacent runners should be loosely bolted together through a 2 by 4, which is placed on edge between them. The middle 2 by 4 should project behind from 4 to 5 feet, and from its end a strong wire should be stretched to the outer back corner of each sled. This wire and the 2 by 4 brace the "double" hopperdozer so that it can be drawn by two teams, one hitched at each end. Being flexible in the middle, it can be used on very uneven ground that will sometimes throw the ends much higher or much lower than the middle. Of course the screens at the back must be arranged so as not to interfere. The wide sweep (30 feet) of this hopperdozer enables the ground to be covered rapidly, which is very important during severe outbreaks, and the teams are so far apart that they do not drive many grasshoppers before them.

An improved hopperdozer, which has been called the grasshopper catcher and which eliminates the disagreeable features incident to the use of crude petroleum, tar, and other sticky substances, has been devised for use in Utah.¹ This machine can be run over hay and grain crops, sugar beets, and potatoes; in fact, over practically everything except corn and ripening grain. It has been used quite successfully on seed alfalfa by running over the field about every 10 days. The details of the machine as illustrated (fig. 13) should enable anyone to make one of them without difficulty.

The principle of the machine is very simple—a box about 2 feet square and 16 feet long on runners, and a 2 by 4 extending out 4 feet at each end, to which a horse is attached. The horses then travel 24 feet apart, driving the grasshoppers in until most of them are in front of the 16-foot machine. A rope fastened to the hame on the inside of each horse and dragged just in front of the machine

¹ Ball, E. D., Utah Agricultural Experiment Station, Bul. 138, pp. 108 to 111.

causes the "hoppers" to jump just as the machine gets to them. The front of the machine is made of tin and is about $2\frac{1}{2}$ feet high and slightly curved. This front does not extend quite down to the bottom, and about 2 inches in front of it and about 4 inches high there is a false front, a second piece of tin, which curves back down and into the box. A grasshopper hitting the tin face can not get a foothold, is perfectly helpless, and slides down between the two pieces of tin, strikes the curve, and is thrown well back into the box, far enough so that he can not see the opening through which he entered. The top and back of the box are made of wire mosquito netting and the hopper immediately jumps toward the light and clings to the netting, never seeking the hole through which he came in.

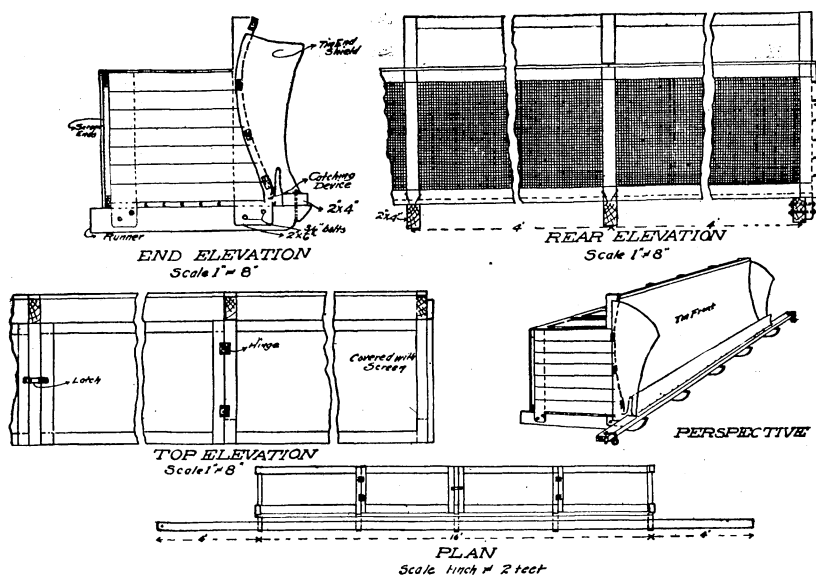


FIG. 13.—An improved machine for catching grasshoppers. (Ball.)

Several bushels can be gathered in this way before they will shake down onto the bottom sufficiently to choke up the front opening. As soon as this happens the front opening should be closed with gunny sacks or similar material and the hoppers can be shoved out into sacks and used to feed chickens or dumped into a trench and buried. As a temporary substitute for the tin front oilcloth may be used. A 6-inch board, hinged to the bottom of the box and extending the full length, about 5 inches back of the front, could be arranged to fold down and close the front while at rest, or stand up at a slight angle to keep the hoppers from rolling down and choking the opening.

The material for such a machine will cost about \$20, and anyone with a saw and hammer can make one in a very short time. The

runners should be spaced so as to fit sugar beet or potato rows, if the machine is to be used on these crops.

A machine, if protected, will last for years, and, as it takes 24 feet at a sweep, it will cover 40 to 50 acres in a day. As there is no expense to the operation except the team and a man to drive, or preferably two small boys to ride the horses, the cost per acre is trifling.

It is not possible to catch all the grasshoppers by going over a field once, but under favorable conditions a very large percentage of them can be caught. If the crop is fairly high the best time to catch the grasshoppers will be in the morning and evening. At these times they are roosting and are quite sluggish. On low crops the hot part of the day, when the grasshoppers jump readily, will be the best time. If the tin front is kept bright and shiny the grasshoppers apparently are not able to see it at all and fly against it readily. Six to 10 bushels of grasshoppers have been collected in an hour with one of these machines where the insects were numerous and conditions favorable, and 30 to 40 bushels a day taken from fields where they did not appear to be very abundant.

BURNING.

Sometimes many grasshoppers hatch in dead vegetation, where they can be destroyed by burning. This frequently occurs on buffalo sod, in neglected fields, or along roadsides. Burning is then the cheapest and most effective means of killing them. If there is not enough dead vegetation to carry the fire, some old hay or straw scattered through the infested area will help to produce enough heat to kill the insects. Opportunities for destroying native grasshoppers by burning should not be neglected. A sufficient number can hatch in one-fourth of an acre of sod to ruin a neighboring garden, yet half a day's work and a load of straw or old hay would burn them all.

UTILIZATION OF POULTRY.

Where grasshoppers are an annual pest, farmers can protect their crops and make a profit on the insects by raising poultry to catch them. The value of chickens and turkeys in destroying grasshoppers is proved anew by each succeeding outbreak, yet comparatively few farmers utilize them as a means of control.

During the late nineties many turkeys were raised to catch grasshoppers on the valley lands along the Solomon River in northern Kansas. Children herded the flocks where grasshoppers were the most destructive, and so successful was this method of saving crops that more farmers adopted it every year until that series of grasshopper outbreaks ended.

Near Scott City, Kans., during 1911, the second crop of alfalfa on a 100-acre field was badly damaged. The owner secured about 100 turkeys and turned them into the field. When the writer visited the place during the third week of August a few of the lesser migratory grasshoppers that could escape capture by flight were the only ones present. The alfalfa was uninjured and was then about 18 inches high.

In June, 1912, the writer constructed a portable henhouse for about 36 grown chickens. It was located on or along the edges of grasshopper-infested fields, being moved to a new place when no "hoppers" were left near by. This flock was fed only a little grain, and while not quite so many eggs were obtained from the hens in comparison with hens handled in the ordinary way, many grasshoppers were caught and the hens acquired such a taste for them that upon being returned to the barnyard they ranged far and near in search of insects.

The Kansas Experiment Station at Garden City bought several hundred chicks in an effort to save the crops during the severe grasshopper outbreak of 1913. A wooden framework, on low trucks, constructed of 2 by 4 material, was built and covered outside with poultry netting and inside with canvas. This portable chicken house was easily hauled from place to place, and was considered the most effective means yet adopted in destroying grasshoppers.

During 1913, near Garden City, rhubarb was attacked by grasshoppers that were rapidly stripping the leaves. The gardener placed in separate coops near it three hens with a total of about 40 active chicks. A few days later the rhubarb was free from grasshoppers and the chicks were catching others in adjacent parts of the garden.

UTILIZATION OF HOGS.

Hogs of all ages become very fond of grasshoppers whenever they are allowed the run of infested land. They are reported as efficient destroyers of both grasshoppers and their eggs. A small lot in a field which had been left for alfalfa seed was fenced as pasture for a few hogs. Grasshoppers damaged the entire field except in the hog lot, where a good crop of seed was set.

PROTECTING SUGAR BEETS, TRUCK CROPS, AND GARDENS.

Land prepared for sugar beets is usually plowed more than 10 inches deep. This is often done late in the fall or early in the winter. Throughout the summer the growing beets require frequent cultivation, which drives away grasshoppers that wish to lay eggs. Digging the beets in the fall stirs the surface soil so much that any egg capsules in it are injured or exposed. Only along the edges of fields and, in irrigated districts, on the banks of ditches is there any danger of eggs being left undisturbed.

Many truck and garden crops are grown on land that is plowed deep late in the fall or during the winter. They also require frequent summer cultivation and, with some, the ground is stirred by harvesting. Consequently there is not much danger that grasshoppers will lay eggs in such fields. From the facts mentioned it is evident that grasshopper damage to sugar beets, truck crops, and gardens is the result of invasion from adjoining infested land.

If many grasshoppers are present during August and September a search should be made to locate their eggs. Clumps of grass should be chopped out and torn to pieces. Here and there in suspected buffalo sod a square foot of ground should be examined to a depth of about 2 inches for eggs. Where the soil is more easily worked the spaces examined may be a yard square. An average over a large area of one capsule of eggs per square yard means a severe outbreak the next year. From each capsule that remains sound 25 to 150 young may hatch. Spots well suited to egg laying are often more heavily infested than this.

When the eggs have been located, measures for their destruction can be applied. These should be delayed until the parent grasshoppers die, in order that no more eggs may be deposited. If the egg-infested land requires plowing for the next year's crop, no other treatment need be given. When plowing is not required, the harrow or disk may be used. Suitable treatment should be given the edges of fields, ditch banks, turn rows, abandoned fields, roadsides, or any other places where eggs are to be found. Scattering clumps of egg-infested grasses should be uprooted, even when the surrounding land receives no treatment.

Where the eggs can not be destroyed, the infested area should be watched and the young killed when they hatch in the spring. On waste land, pastures, and sod that can be burned over, fire is the best means of destroying them. If it can not be used, and young chicks or turkeys are available, these should be put into a portable henhouse and located between the infested land and any field into which the young grasshoppers are likely to go. The flock can be moved to a fresh location as the land near by is cleared of "hoppers." In this way the grasshoppers can be worked back from the field and the danger of invasion lessened. If the infested area is large, the poultry may be brought almost to maturity with a comparatively small outlay for feed and with a constantly decreasing number of grasshoppers that will be left to deposit eggs in the fall.

There should be no delay when grasshoppers hatch in great numbers over a large area, for the expense and difficulty of combating them increase rapidly as they grow larger. If no other means of control are ready for use at once, the poisoned bait or the hopperdozer must be relied upon. The time available for the work, the cost of ap-

plication, and perhaps other factors must be considered in choosing between the two methods. The bait is cheaper, less time is required to treat land with it than with the hopperdozer, and it can be prepared in any quantity. With a 2-gallon pail of bait one can sow in fields and in locations the character of which makes the use of the hopperdozer impossible. Consequently this method is most frequently chosen.

If grasshoppers have already invaded a beet field or garden, the bait must be applied all over it. Several applications at intervals of two days are sometimes necessary to check the injury. The infested land from which the grasshoppers are coming should also be treated vigorously with the most suitable method. Around the edges of fields, and in fields where the crop permits it, a tubful of bait can be placed on a sled or in a wagon, and the driver can sow from it, thus getting over the ground rapidly. The "hoppers" in fields of low-growing crops can be caught with a hopperdozer if time permits and teams are available. But in fields of tall-growing crops, where many grasshoppers are on the plants at all times, a modified bait should be used. It is prepared by using three or four times the usual quantity of sirup and correspondingly less water. It should be applied by throwing small quantities among the tops of the plants so that it will stick to the leaves or blades. There it will attract the grasshoppers immediately. The poison is washed off by rains or shaken off by handling, so there is no danger to animals that feed on crops treated in this manner. This sticky bait should also be thrown among the tops of bushes or trees in which the insects feed.

ESSENTIALS FOR SUCCESSFUL WORK.

The most frequent cause of failure to check grasshopper outbreaks when methods of control are applied are (1) lack of cooperation among the landowners of the infested community and (2) misdirected or careless application of recommended control measures. The former, however, is more often the cause.

In many localities part of the land is held by speculators, who often permit it to lie idle for several years in succession. If such land is in sod, grasshoppers use only the outskirts for depositing eggs, but if it has been broken and then neglected, a sufficiently heavy growth of weeds is often produced to make it a breeding place for large numbers of grasshoppers. Where there is much of such land in a community the grasshoppers must be destroyed on it, as well as on the edges of cultivated fields, along roadsides, or on pasture land; otherwise it becomes the center from which "hoppers" scatter to the crops on adjoining fields.

